Securely Taking on New Executable Software of Uncertain Provenance (STONESOUP) Program Overview

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STONESOUP Program

- Program kicked off September 2010
- BAA closed
- Performers:
  - GrammaTech
  - SAIC
  - Kestrel Institute
  - University of Illinois Urbana-Champagne
  - Columbia University
- Test and evaluation team is led by MITRE

STONESOUP Goals

- Provide end users/enterprises the capability to transform a software executable to create a safer version
- Automatically analyze, confine, and diversify software without regard to its provenance
- Address implementation defects, not design defects
- Address inadvertent defects, not malicious logic

Technical Approach

- Analysis
  - Must be fully automated
- Confinement
  - Render weaknesses identified by analysis unexploitable
- Diversification
  - Address residual risk to raise the cost or lower the impact of an attack on the software

Targeted Software

- Each proposal chose a class of software to target from among:
  - A type-safe language (Java or C#--no proposer chose C#)
  - A non-type-safe languages (C or C++)
  - Binary executables (x86 Windows or x86 Linux)

Targeted Weaknesses

- Each proposal chose six classes of weakness to target from among:
  1. Number handling
  2. Tainted data/Input Validation errors
  3. Error handling
  4. Resource drains
  5. Injections (SQL, command)
  6. Concurrency handling/Race conditions
  7. Buffer overflows/Memory safety violations (C, C++, binary only)
  8. Null pointer errors (C, C++, binary only)

Program Balance

- The STONESOUP Program has achieved good coverage over the space of possible targets:

	1	2	3	4	5	6	7	8
A	✓✓	✓✓	✓✓	✓	✓✓	✓		
B	✓✓	✓✓	✓✓		✓	✓	✓✓	✓
C	✓	✓✓	✓✓	✓✓	✓✓	✓	✓✓	✓✓

Program Metrics (1)

- STONESOUP metrics focus on soundness: identification and neutralization of nearly all vulnerabilities of a given class:
  - Phase 1 (18 mos): Solutions must find and render unexploitable 75% of the vulnerabilities in a suite of small (<10K SLOC) test programs
  - Phase 2 (12 mos): 90% of the phase 1 vulnerabilities and 80% of the vulnerabilities in a suite of medium-sized (~100K SLOC) test programs
  - Phase 3 (18 mos): 95% of the phase 1&2 vulnerabilities and 90% of the vulnerabilities in a suite of large (~500K SLOC) test programs
  - For each phase a small percentage of C, C++, or binary test programs may be rejected (not processed)

Program Metrics (2)

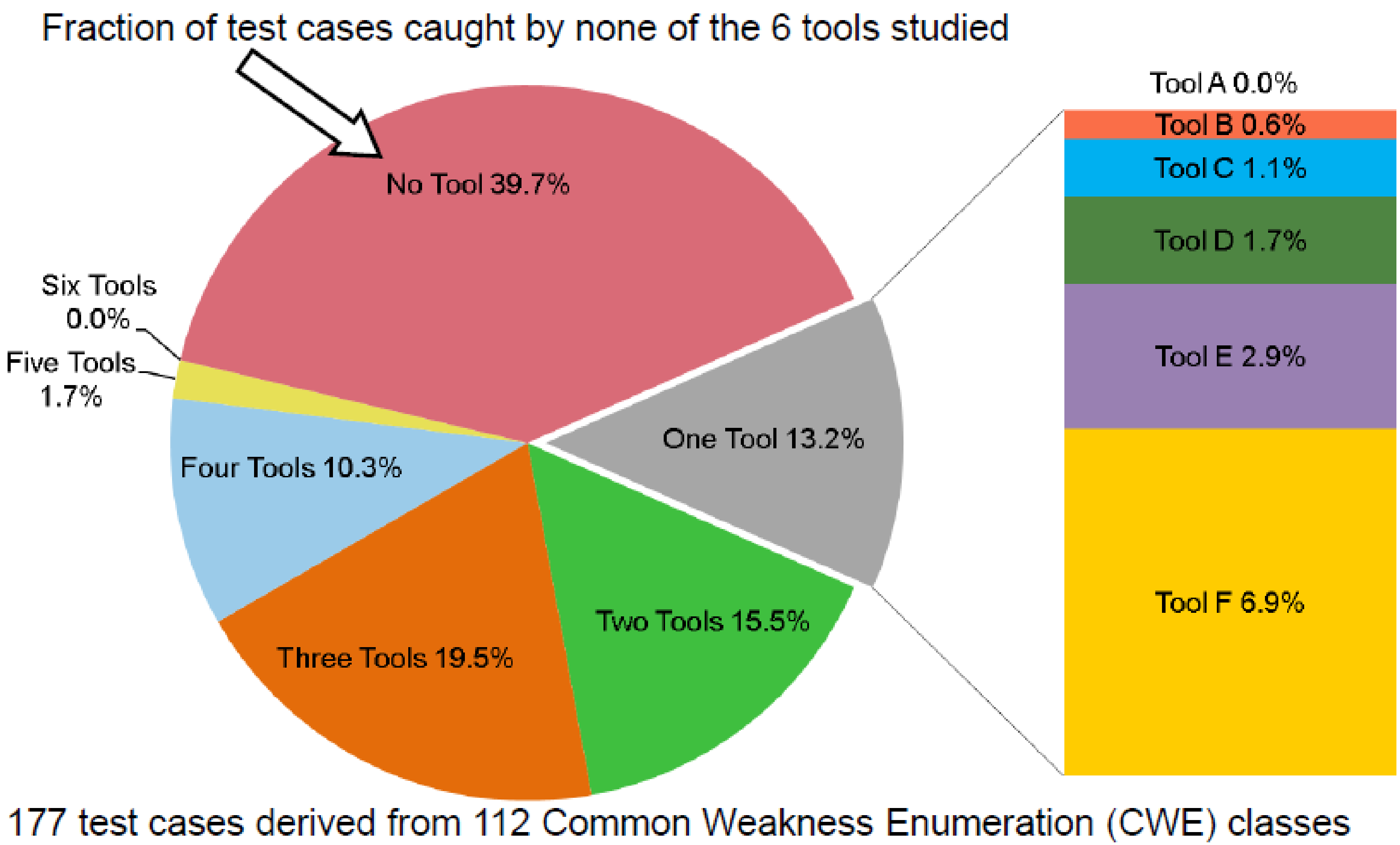
- Phase 3 includes
  - Measurement of the performance overhead of the processed software (no more than +10% increase in running time is sought)
  - Assessment of the additional work factor imposed on an attacker due to the diversification (measures to be determined)

Program Reality Check

- Test and Evaluation team has been tasked by Program Manager to develop a baseline solution using an integrated toolbox of commercial off the shelf products
  - Will be evaluated in conjunction with STONESOUP Test and Evaluation to provide context
  - Likely will not be fully automated/integrated: goal is to get reasonably close given resource constraints
  - Some custom generation of “rules” may be allowed, but not custom tool development

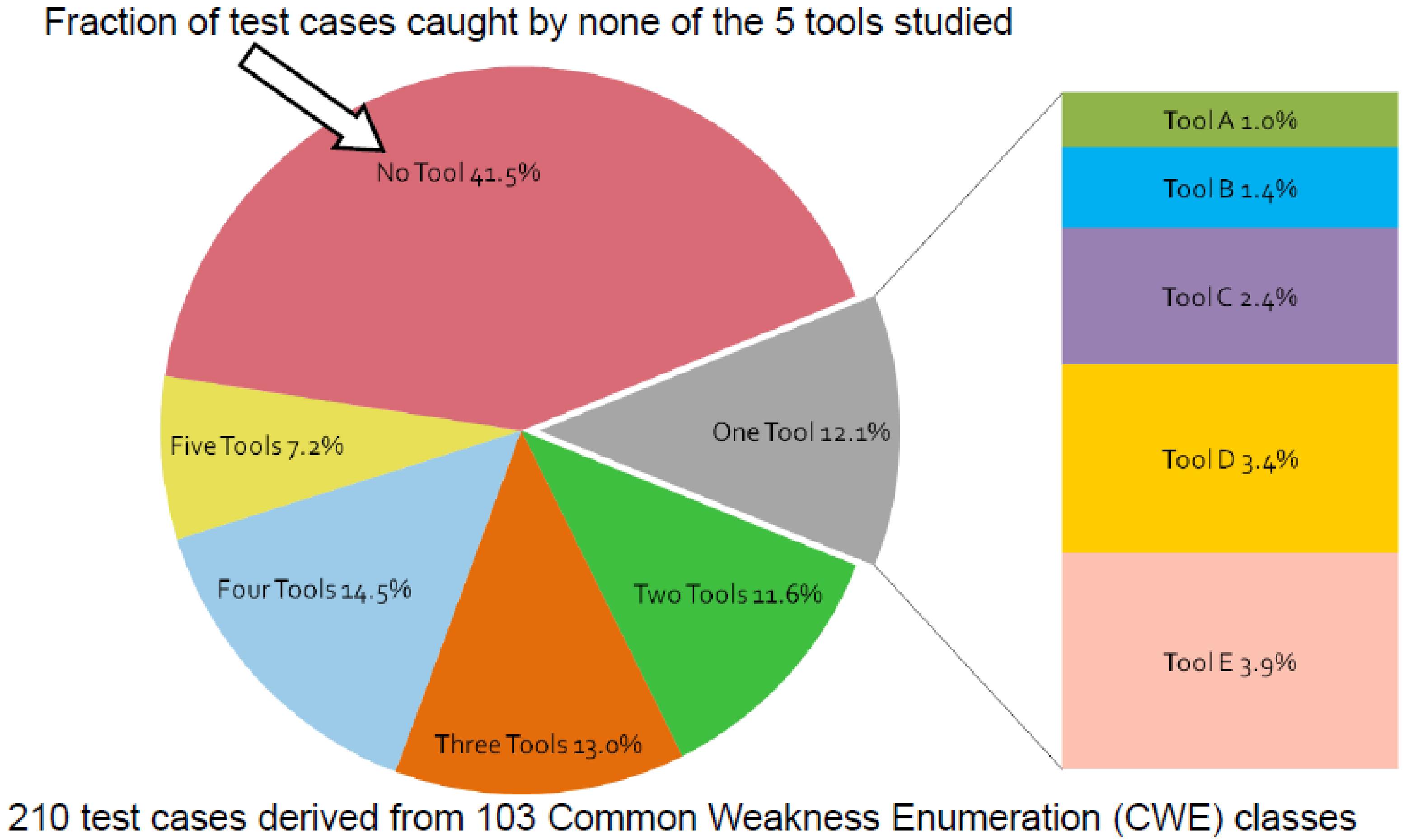
Analysis Advances Sought (1)

- Results of a 2009 study of Java tools:



Analysis Advances Sought (2)

- Results of a 2009 study of C/C++ tools:



Analysis Advances Sought (3)

- Current analysis techniques lead to an end-user decision
  - False positives must be identified by human review
  - False negatives are common
  - The end-user must select and apply countermeasures
- STONESOUP analysis must lead to automated response
  - Program metrics are designed to drive advances in both precision and soundness
    - False positives could result in unnecessary countermeasures, degrading performance
    - False negatives could result in failure to meet the test and evaluation targets

Confinement Advances Sought (1)

- STONESOUP confinement must be precise enough to limit performance overhead
- Confinement may be software or hardware based, but should use widely available commodity systems
- Automation requirements drive novel approaches to error response and recovery

Confinement Advances Sought (2)

- Weakness targeting requirements drive novel mixtures of confinement techniques
  - Precise/sound input filtering
  - Runtime inspection of program state
  - Resource virtualization
  - Adaptive code rewriting
- Diversification requirements drive exploration of variations within each confinement technique

Diversification Advances Sought (1)

- Current diversification techniques address generic attack elements
  - Program state data is more difficult to find or predict
  - Faulty program states are more difficult to replicate
  - Exploitation impact is more difficult to predict
- Current diversification is rarely driven by analysis
  - Vulnerabilities may simply be shuffled around
  - Uncertain where and how much diversification can be applied due to lack of data dependency information that analysis could provide

Diversification Advances Sought (2)

- STONESOUP seeks diversification techniques that protect against specific classes of weakness
  - Program requires effectiveness estimates for chosen diversification techniques against a targeted weakness class
- Diversification techniques can be mixed
  - Address space layout randomization + instruction set randomization + function call variants, etc.
  - Techniques can be adaptive
  - Each executing instance may be unique, and thus at most one instance can be exploited with each malicious input

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